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(54) **MULTI-CHIP MODULE FOR A MULTI-MODE RECEIVER AND METHOD THEREFOR**

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(57) **ABSTRACT**

In one form, a multi-chip module for a multi-mode receiver includes an MCM substrate and first and second demodulator die. The MCM substrate has first and second satellite input ports, first and second terrestrial/cable input ports, and first and second transport stream ports. The first demodulator die has a satellite port coupled to the first satellite input port of the MCM substrate, a terrestrial/cable port coupled to the first terrestrial/cable input port of the MCM substrate, and first and second transport stream ports coupled to the first and second transport stream ports of the MCM substrate. The second demodulator die has a satellite port coupled to the second satellite input port of the MCM substrate, a terrestrial/cable port coupled to the second terrestrial/cable input port of the MCM substrate, and first and second transport stream ports coupled to the first and second transport stream ports of the MCM substrate.

20 Claims, 7 Drawing Sheets

300
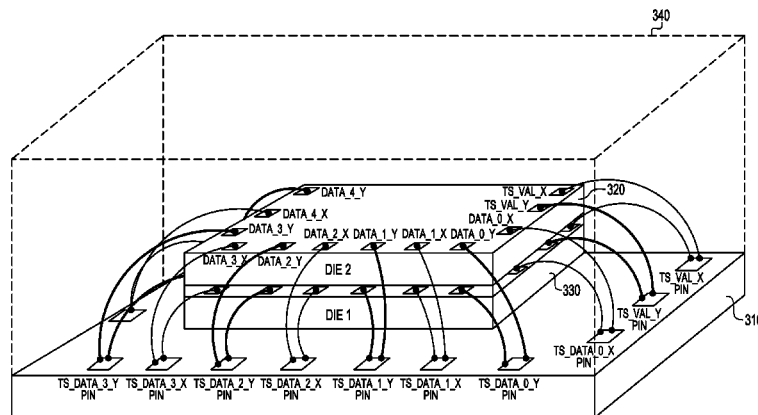
(51) **Int. Cl.**

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H04N 21/462	(2011.01)
H04N 21/61	(2011.01)
H04N 5/455	(2006.01)
H04N 5/268	(2006.01)

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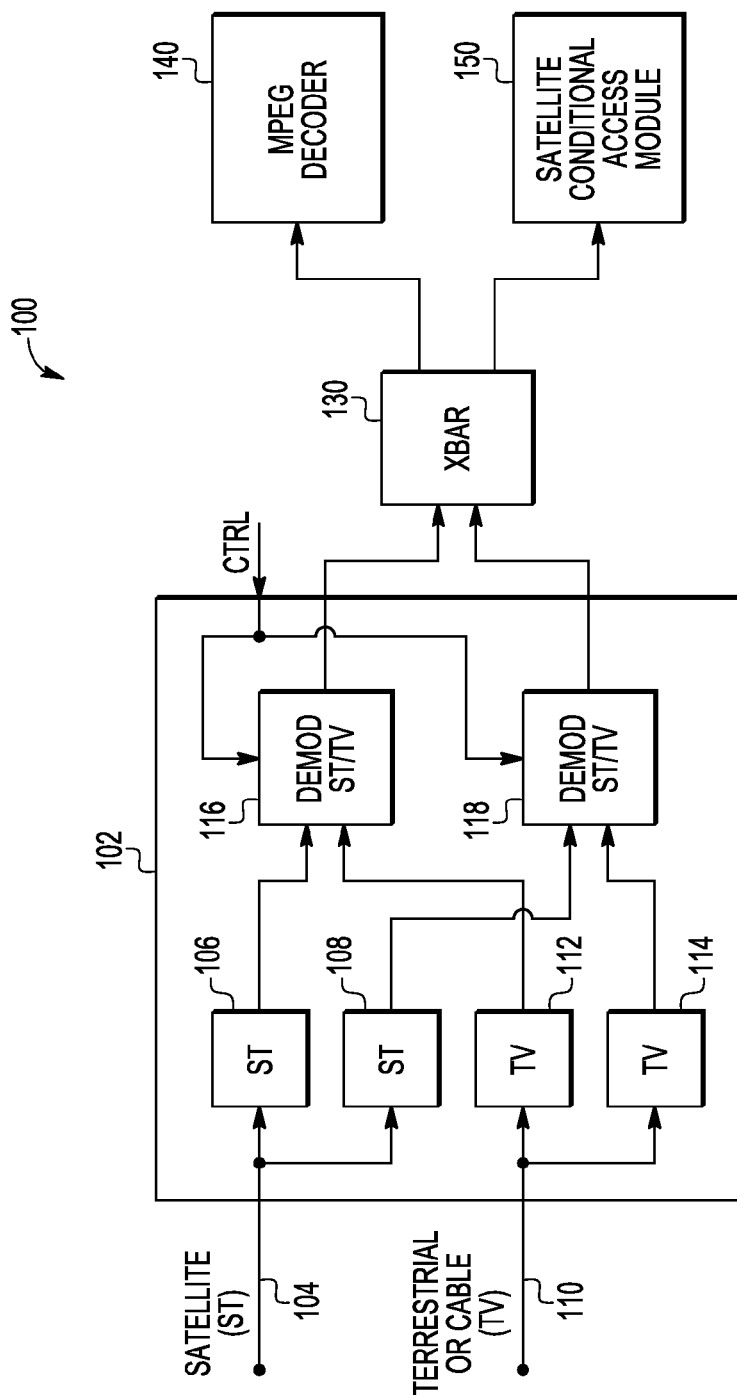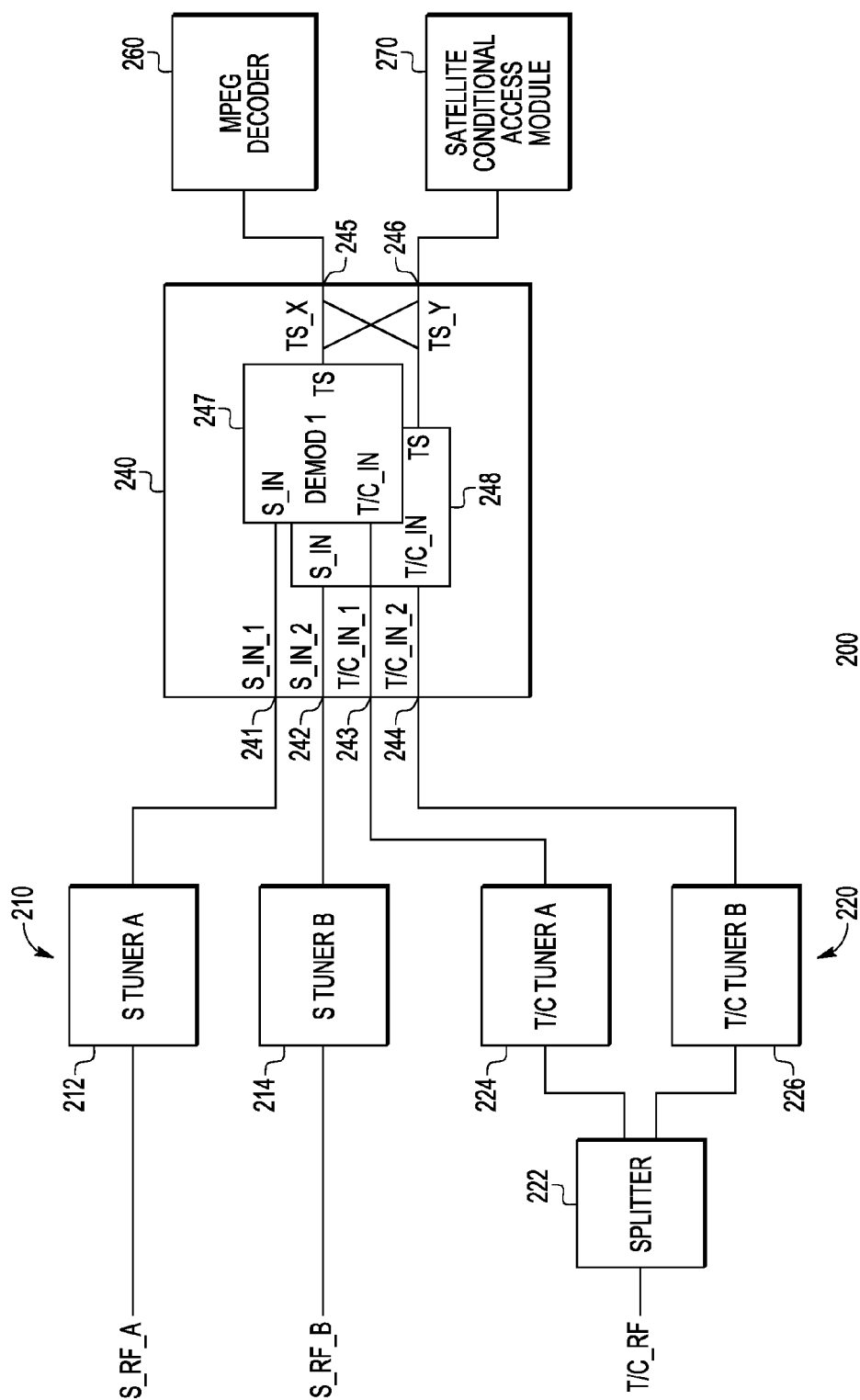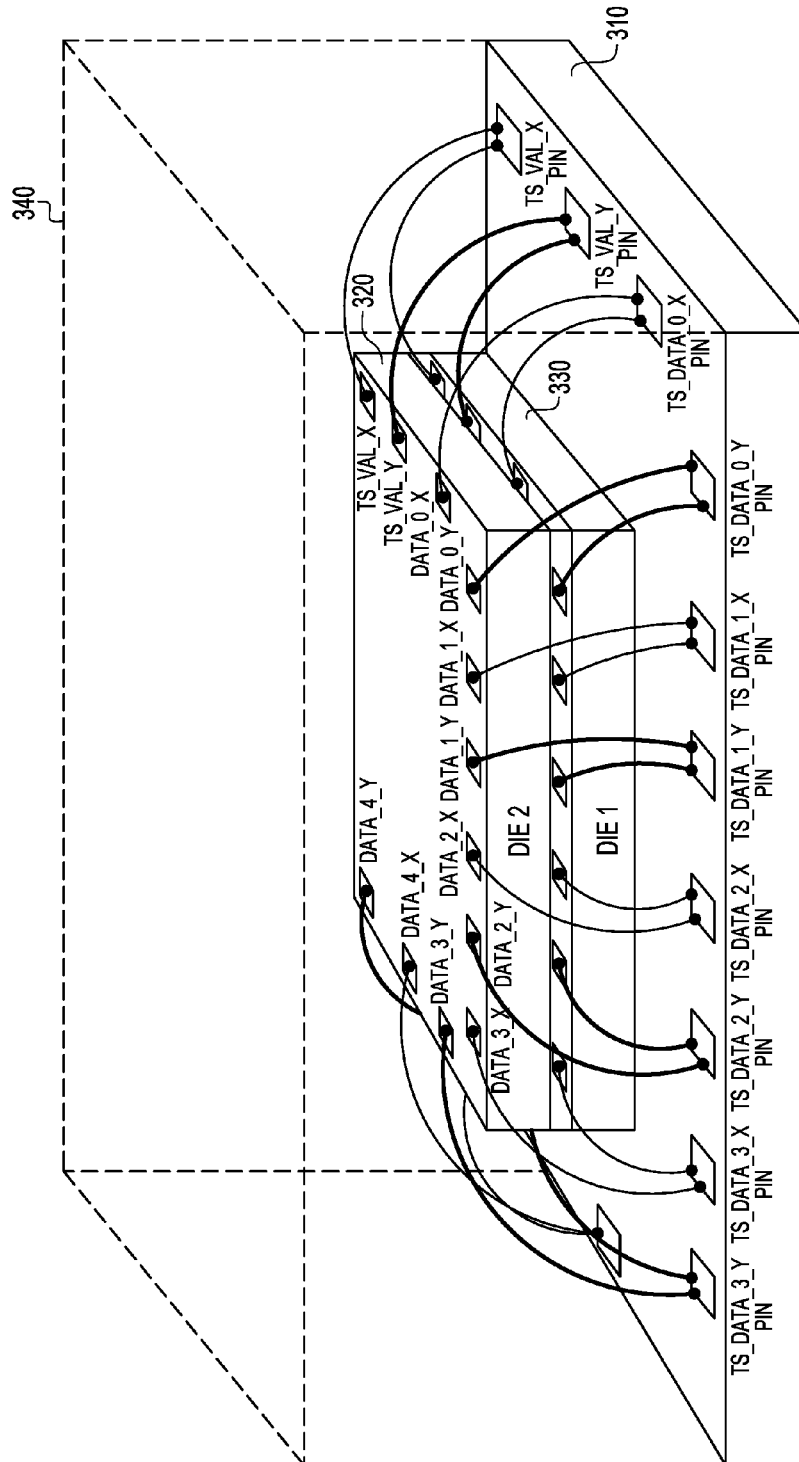
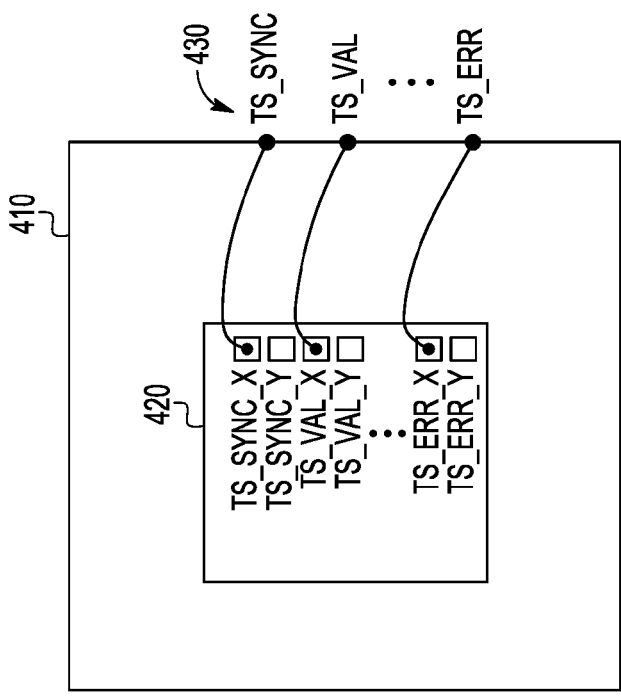* cited by examiner

FIG. 1
- PRIOR ART -

FIG. 2

200
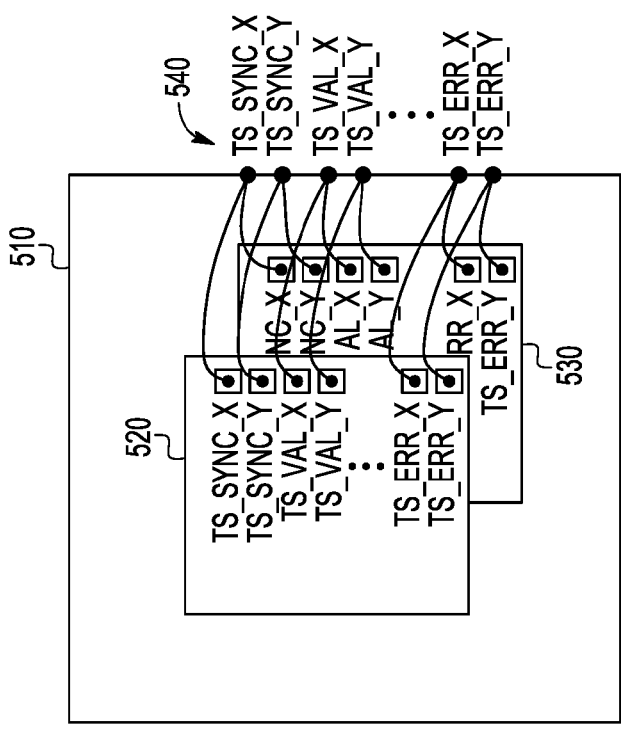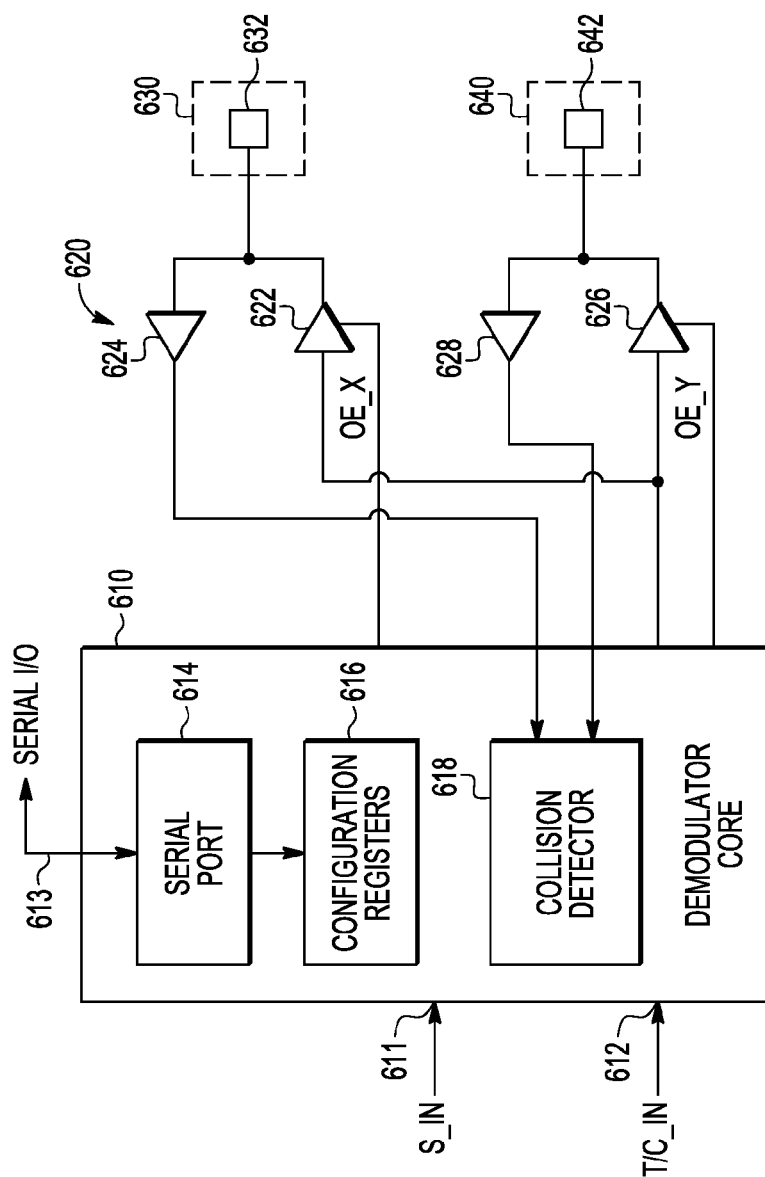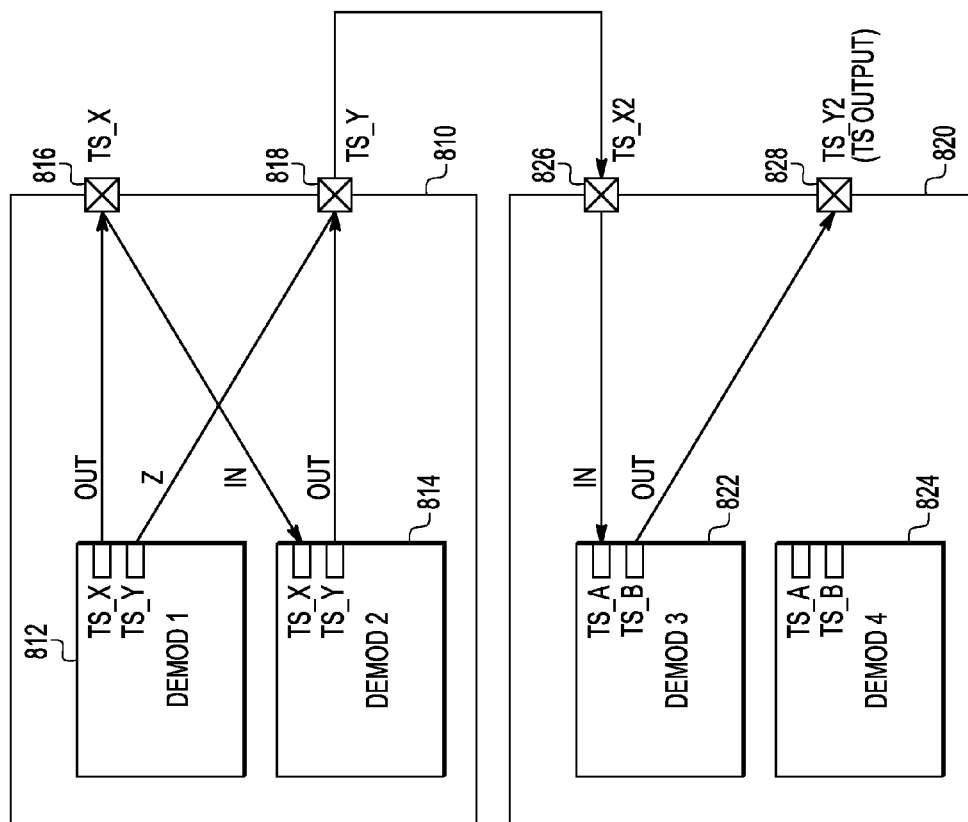
FIG. 3

300

FIG. 5

FIG. 4

600

FIG. 6

FIG. 7

FIG. 8

800

MULTI-CHIP MODULE FOR A MULTI-MODE RECEIVER AND METHOD THEREFOR

This application is a division of prior application Ser. No. 14/195,575, filed Mar. 3, 2014, entitled "Demodulator and Multi-Chip Module for a Multi-Mode Receiver and Method Therefore".

FIELD OF THE DISCLOSURE

The present disclosure relates generally to receivers, and more particularly to multi-mode receivers such as television receivers capable of receiving and demodulating different input signal streams.

BACKGROUND

Certain television receivers support multiple simultaneous channel reception and demodulation of signals from different types of signal sources. For example, a television may support both satellite and terrestrial/cable input signal sources, and the user may desire to watch a satellite channel while recording a terrestrial/cable channel or vice versa. This diversity of input signal sources makes it difficult to design cost-effective receivers that support all desired modes of operation. For example, in a receiver with two or more television demodulators, the outputs from the demodulators may need to be multiplexed or rerouted to different video decoders based on the desired mode of operation. This selection of features has necessitated costly circuits such as discrete crossbar switches to support all desired functions. While modern integrated circuit manufacturing technologies have resulted in significant component cost reduction, further cost reduction is desirable while maintaining all desired operational modes.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure may be better understood, and its numerous features and advantages made apparent to those skilled in the art by referencing the accompanying drawings, in which:

FIG. 1 illustrates in block diagram form a multi-mode receiver known in the prior art;

FIG. 2 illustrates in block diagram form a multi-mode receiver according to one embodiment;

FIG. 3 illustrates a perspective view of a multi-chip module implementing the multi-mode receiver of FIG. 2;

FIG. 4 illustrates in block diagram form a demodulator using a single demodulator die to form a low-cost receiver;

FIG. 5 illustrates in block diagram form a demodulator using multiple demodulator die to form a high-function receiver;

FIG. 6 illustrates in block diagram form a demodulator that can be used as one of the demodulators of any of FIGS. 2-5;

FIG. 7 illustrates in block diagram form a demodulator like the demodulator of FIG. 6 illustrating further details of the collision detector; and

FIG. 8 illustrates in block diagram form a receiver using the demodulator die of FIGS. 6 and 7 to support a channel bonding mode.

The use of the same reference symbols in different drawings indicates similar or identical items. Unless otherwise noted, the word "coupled" and its associated verb forms include both direct connection and indirect electrical con-

nection by means known in the art, and unless otherwise noted any description of direct connection implies alternate embodiments using suitable forms of indirect electrical connection as well.

DETAILED DESCRIPTION

In one form, a multi-chip module for a multi-mode receiver includes an MCM substrate and first and second demodulator die. The MCM substrate has first and second satellite input ports, first and second terrestrial/cable input ports, and first and second transport stream ports. The first demodulator die has a satellite port coupled to the first satellite input port of the MCM substrate, a terrestrial/cable port coupled to the first terrestrial/cable input port of the MCM substrate, and first and second transport stream ports coupled to the first and second transport stream ports of the MCM substrate. The second demodulator die has a satellite port coupled to the second satellite input port of the MCM substrate, a terrestrial/cable port coupled to the second terrestrial/cable input port of the MCM substrate, and first and second transport stream ports coupled to the first and second transport stream ports of the MCM substrate. By connecting transport stream ports of the two demodulator die in common to corresponding transport stream ports of the MCM substrate, the MCM can be made more cheaply by eliminating the need for a discrete crossbar switch.

In another form, a demodulator for a multi-mode receiver includes a first input port, a second input port, a first transport stream port, a second transport stream port, a demodulator core, and a switching circuit. The demodulator core is responsive to an input from a selected one of the first input port and the second input port for providing a first transport stream signal to an output thereof. The switching circuit is responsive to a first mode for coupling the output of the demodulator core to a selected one of the first and second transport stream ports. In one configuration, the demodulator can be used by itself to form a low-cost receiver by connecting only one of its transport stream output ports to an integrated circuit package or MCM. In another configuration, the demodulator can be combined with one or more similar demodulators in a multi-chip module or other collection of circuits to form a high function receiver for applications such as high-end televisions and set-top boxes.

In yet another form, a method includes receiving a first input signal on a first input port of a first demodulator die, receiving a second input signal on a second input port of the first demodulator die, demodulating a selected one of the first input signal and the second input signal to provide a first demodulated output signal, switching the first demodulated output signal to a first transport stream port in response to a first mode of operation, and switching the first demodulated output signal to a second transport stream port in response to a second mode of operation. This method can be used, for example, to implement a television receiver which receives both satellite and terrestrial/cable signals to support multiple modes of operation.

FIG. 1 illustrates in block diagram form a multi-mode receiver 100 known in the prior art. Multi-mode receiver 100 includes generally a tuner portion 102, a crossbar switch 130 labeled "XBAR", a decoder 140 capable of decoding a Motion Picture Experts Group (MPEG) signal stream labeled "MPEG DECODER", and a decoder 150 labeled "SATELLITE CONDITIONAL ACCESS MODULE".

Tuner portion 102 includes four tuners 106, 108, 112, and 114 and two demodulators 116 and 118. Tuner 106 is a

satellite tuner labeled "ST" having an input adapted to be coupled to a first type of signal source such as a satellite radio dish antenna, and an output. Tuner 108 is a satellite tuner (ST) having an input adapted to be coupled to the first type of signal source, and an output. Tuner 112 is a television tuner labeled "TV" having an input adapted to be coupled to a second type of signal source such as a television antenna, cable, and the like, and an output. Tuner 114 is a television tuner (TV) having an input adapted to be coupled to the second type of signal source, and an output.

Demodulator 116 has a first input connected to the output of tuner 106, a second input connected to the output of tuner 112, a control input for receiving a control signal labeled "CTRL", and an output. Demodulator 118 has a first input connected to the output of tuner 108, a second input connected to the output of tuner 114, a control input for receiving signal CTRL, and an output.

Crossbar switch 130 has a first input connected to the output of demodulator 116, a second input coupled to the output of demodulator 118, and first and second outputs. Decoder 140 has an input connected to the first output of crossbar switch 130, and an output (not shown in FIG. 1). Decoder 150 has an input connected to the second output of crossbar switch 130, and an output (not shown in FIG. 1).

Note that various signals are depicted herein as single signal lines for simplicity but actually include multiple individual signal lines. For example, the satellite and terrestrial or cable inputs are usually differential signals, and the outputs of demodulators 116 and 118 are transport stream signals defined by the MPEG standard and include twelve digital signal lines. Moreover the CTRL signal is actually a set of control signals that are different for each demodulator.

In operation, multi-mode receiver 100 is useful in applications such as multi-tuner televisions or set-top boxes to provide a variety of user-defined functions. For example if a user wants to record a satellite program while watching a cable program, then a host (not shown in FIG. 1) would provide the CTRL signal in a state to enable demodulator 116 to select its first input and demodulator 118 to select its second input. The host would also configure crossbar switch 130 to switch the output of demodulator 116 to decoder 150 to decrypt the video signal stream and decode the MPEG data, while switching the output of demodulator 118 to decoder 140 to decode the terrestrial or cable-based MPEG data stream. By including four tuners and providing the output of one cable tuner and one terrestrial/cable tuner to each demodulator, multi-mode receiver 100 provides the user with significant flexibility of functions.

Moreover, the components in tuner portion 102 can take advantage of modern integrated circuit technology to provide a low cost and flexible implementation. For example, each demodulator can be formed using a separate integrated circuit die that can be combined with another similar or identical die for a multi-tuner implementation. Alternatively, the same demodulator die can be used as the sole demodulator for a low-cost implementation. Moreover, the two demodulator dies can be designed using low-voltage complementary metal-oxide-semiconductor (CMOS) manufacturing processes and can be combined in a multi-chip module for further cost reduction. While these techniques enable low-cost designs, further cost reduction is desirable while retaining the same functionality.

FIG. 2 illustrates in block diagram form a multi-mode receiver 200 according to one embodiment. Multi-mode receiver 200 includes generally a satellite tuner section 210,

a terrestrial/cable tuner section 220, a multi-chip module (MCM) 240, an MPEG decoder 260, and a satellite conditional access module 270.

Satellite tuner section 210 includes a satellite tuner 212 labeled "S TUNER A" and a satellite tuner 214 labeled "S TUNER B". Satellite tuner 212 has an input for receiving a radio frequency (RF) input signal from a satellite labeled "S_RF_A", and an output. Satellite tuner 214 has an input for receiving an RF input signal from a satellite labeled "S_RF_B", and an output.

Terrestrial/cable tuner section 220 includes a splitter 222, a terrestrial/cable tuner 224 labeled "T/C TUNER A", and a terrestrial/cable tuner 224 labeled "T/C TUNER B". Splitter 222 has an input adapted to be connected to, for example, a residential cable access point, and first and second outputs. Terrestrial/cable tuner 224 has an input connected to the first output of splitter 222, and an output. Terrestrial/cable tuner 226 has an input connected to the second output of splitter 222, and an output.

MCM 240 includes a first demodulator die 247 and a second demodulator die 248, and has a first satellite input port 241 connected to the output of satellite tuner 212 for receiving a signal labeled "S_IN_1", a second satellite input port 242 connected to the output of tuner 214 for receiving a signal labeled "S_IN_2", a first terrestrial/cable input port 243 connected to the output of terrestrial/cable tuner 224 for receiving a signal labeled "TC_IN_1", a second terrestrial/cable input port 244 connected to the output of tuner 226 for receiving a signal labeled "TC_IN_2", a fifth MCM terminal 245 for providing a transport stream signal labeled "TS_X" and a sixth terminal 246 for providing a transport stream signal labeled "TS_Y". MCM 240 includes a first demodulator die 247 and a second demodulator die 248. Demodulator die 247 has a satellite input terminal labeled "S_IN" connected to MCM terminal 241, a terrestrial/cable terminal labeled "T/C_IN" connected to first terrestrial/cable input port 243, a first transport stream output terminal connected to first transport stream port 245, and a second transport stream output terminal connected to second transport stream port 246. Demodulator die 248 has a satellite input terminal also labeled "S_IN" connected to second satellite input port 242, a terrestrial/cable terminal also labeled "T/C_IN" connected to MCM terminal 244, a first transport stream output terminal connected to first transport stream port 245, and a second transport stream output terminal connected to second transport stream port 246.

MPEG decoder 260 has an input terminal connected to first transport stream port 245, and an output (not shown in FIG. 2). Satellite conditional access module 270 has an input terminal connected to second transport stream port 246, and an output (not shown in FIG. 2).

Unlike multi-mode receiver 100 of FIG. 1, multi-mode receiver 200 eliminates the need for a discrete crossbar switch, which reduces overall cost by reducing printed circuit board space and chip count. As will be described in greater detail below, the multi-mode receiver 200 uses demodulator dies 247 and 248 and distributes the output signal switching function between the two. Thus corresponding outputs of each die can be connected to common MCM terminals while still allowing the host to configure multi-mode receiver 200 flexibly during operation. Moreover, each die can be used either in a low cost receiver with a single demodulator, or a high function receiver with two or more demodulators in a common MCM. Each demodulator die includes both a demodulator core and a switching circuit and supports additional functions to provide further flexibility. One of these functions is a failsafe mechanism to

allow the demodulators to independently detect and prevent the harmful effects of a collision if both dies try to drive a single transport stream output. Another function is the ability to connect the dies in a way to perform channel bonding. These additional capabilities will be described further below.

Note that while FIG. 2 shows an MCM with two demodulator die, this approach can be extended to an arbitrary number of demodulator die for receiver applications with even higher functions. Also while FIG. 2 has been described with respect to the MPEG transport stream, any other data transport stream protocol may be used as well, such as the Generic Stream Encapsulated (GSE) protocol.

FIG. 3 illustrates a perspective view of an MCM **300** implementing the multi-mode receiver of FIG. **2**. MCM **300** includes an MCM substrate **310**, a first demodulator die **320**, a second demodulator die **330**, and an encapsulant **340**. MCM substrate **310** is a substrate providing a set of landing pads for wire bonding to corresponding chip signal pads, and a set of corresponding terminals such as solder balls in the case of ball grid array (BGA) packaging or terminals flush with the underside of MCM substrate **310**.

As shown in FIG. **3**, substrate **310** includes a set of landing pads on the top side of MCM substrate **310** corresponding transport streams X and Y including as a set of representative landing pads shown in FIG. **3**. TABLE I shows the complete list of MPEG transport stream signals supported by MCM **300**:

TABLE I

MCM Pin Name	Transport Stream Port	Function
TS_SYNC_X	X	Synchronization signal
TS_VAL_X	X	Valid signal
TS_CLK_X	X	Clock signal
TS_DATA<7:0>_X	X	Data
TS_ERR_X	X	Error signal
TS_SYNC_Y	Y	Synchronization signal
TS_VAL_Y	Y	Valid signal
TS_CLK_Y	Y	Clock signal
TS_DATA<7:0>_Y	Y	Data
TS_ERR_Y	Y	Error signal

In an exemplary embodiment, MCM substrate **310** is a lead frame in which first demodulator die **320** and second demodulator die **330** overlie a paddle, and in which encapsulant **340** is a plastic. First demodulator die **320** is attached to the paddle of MCM substrate **310** using silver filed epoxy for mechanical adhesion to the paddle. Second demodulator die **330** is attached to first demodulator die **320** using a nonconductive adhesive film (not visible in FIG. **3**) of sufficient height to allow the bond wires to extend through the film (wire-on-film) from bonding pads on first demodulator die **320** to corresponding landing pads on MCM substrate **310** without encroachment.

In other embodiments, MCM **300** can be implemented with other well known packaging technologies, such as ceramic, micro-BGA, plastic QFN and the like.

FIG. **4** illustrates in block diagram form a demodulator **400** using a single demodulator die **420** to form a low-cost receiver. Demodulator **400** has a first input port for connecting to a satellite receiver and a second input port for connecting to a terrestrial/cable receiver, neither of which is specifically shown in FIG. **4**. Demodulator **400** provides only a single transport stream output to a transport stream port **430** and includes only a single demodulator die **420** mounted on an integrated circuit substrate **410**. Demodulator die **420** intermixes bond pads of both the TS_X and TS_Y

ports to preserve a regular placement of bond wires even when supporting only a single transport stream output. The bond pads of demodulator die **420** are wire-bonded to landing pads corresponding to the single transport stream output port.

FIG. **5** illustrates in block diagram form a demodulator **500** using multiple demodulator die to form a high-function receiver. Demodulator **500** has a first input port for connecting to a satellite receiver and a second input port for connecting to a terrestrial/cable receiver, neither of which is specifically shown in FIG. **5**. Demodulator **500** provides dual transport stream outputs to a corresponding output port **540** and includes a first demodulator die **520** and a second demodulator die **530** mounted on an integrated circuit substrate **510**. First demodulator die **520** intermixes bond pads of both the TS_X and TS_Y ports to preserve a regular placement of bond wires even when supporting only a single transport stream output. The bond pads of first demodulator die **520** are wire-bonded to landing pads corresponding to the two transport stream output ports. Likewise, the bond pads of second demodulator die **530** are wire-bonded to landing pads corresponding to the two transport stream output ports.

FIG. **6** illustrates in block diagram form a demodulator **600** that can be used as one of the demodulators of any of FIGS. **2-5**. Demodulator **600** includes a demodulator core **610**, a switching circuit **620**, a first transport stream port **630**, and a second transport stream port **640**. Demodulator core **610** includes a first input port **611** for receiving a satellite input signal labeled "S_IN", a second input terminal **612** for receiving a terrestrial/cable input labeled "T/C_IN", a serial input/output terminal **613** for transmitting signals labeled "SERIAL I/O", a serial port **614**, a set of configuration registers **616**, and a collision detector **618**. Serial port **614** controls the serial communication over the SERIAL I/O signals with an external host to receive and store configuration information in configuration registers **616**. The configuration information includes the selection of an input mode which determines whether demodulator core **610** demodulates the S_IN signal or the T/C_IN signal, and the selection of transport stream port X, transport stream port Y, or both transport stream port X and transport stream port Y. According to this latter selected mode, demodulator core **610** activates a signal labeled "OE_X" to select the X port, "OE_Y" to select the Y port, or both OE_X and OE_Y to select both transport stream ports X and Y. Collision detector **618** has first and second inputs, and outputs (not specifically shown in FIG. **6**) for providing a collision signal.

Switching circuit **620** includes a set of input and output buffers for each signal of the transport stream port as described above in TABLE I, of which a representative one transport stream port data is shown in FIG. **6**. Thus switching circuit **620** includes for this one representative transport stream port buffers **622**, **624**, **626**, and **628**. Buffer **622** is an output buffer and has an input connected to the output of demodulator core **610**, an output, and a control input for receiving signal labeled "OE_X". Buffer **624** is a readback buffer and has an input connected to the output of buffer **622**, and an output connected to the first input of collision detector **618**. Buffer **626** is an output buffer and has an input connected to the output of demodulator core **610**, an output, and a control input for receiving a signal labeled "OE_Y". Buffer **628** is a readback buffer and has an input connected to the output of buffer **626**, and an output connected to the second input of collision detector **618**.

First transport stream port **630** includes, for example, twelve terminals each comprising a bonding pad, in which

FIG. **6** illustrates a representative bonding pad **632** connected to the output of buffer **622** and to the input of buffer **624**. Second transport stream port **640** includes, for example, twelve terminals each comprising a bonding pad, in which FIG. **6** illustrates a representative bonding pad **642** connected to the output of buffer **626** and to the input of buffer **628**.

Demodulator **600** includes an additional collision detection function that allows demodulator **600** to detect a collision and to take appropriate actions. If operating properly, software running on the host should configure no more than one of the two or more demodulators to drive output signals on any respective transport stream port. Thus the host sends serial data on serial port **614** to enable the appropriate one or ones of buffers **622** and **626**, while keeping the other one or ones in high impedance mode. However if the host hardware or software malfunctions or the data transmitted to serial port **614** to configure the output buffers malfunctions, then collision detector **618** and readback buffers **624** and **628** provide a failsafe mechanism to disable operation when a collision is detected. For example, suppose that the MCM includes two demodulator die, and both of the two are erroneously configured to drive transport stream port **1** at the same time. In this case, a collision detector **618** on one of the two die will eventually detect a mismatch between the logic state intended to be driven and the logic state actually present on the bus. For example if the first demodulator attempts to drive a logic low value while the second demodulator attempts to drive a high value, the value on the commonly connected transport stream port will assume an intermediate state which one collision detector **618** sees as a mismatch. The demodulator that sees the mismatch will immediately disable all output buffers on the corresponding demodulator die and signal an interrupt to the host. Thus the collision detection mechanism prevents integrated circuit damage by quickly disabling one of the demodulators and by signaling the host so the host can diagnose the cause of the collision.

FIG. **7** illustrates in block diagram form a demodulator **700** like demodulator **600** of FIG. **6** illustrating further details of the collision detector. Demodulator **700** includes switching circuit **620**, first transport stream port **630**, and second transport stream port **640** as previously illustrated in FIG. **6**, and a collision detector **710**. Collision detector **710** includes a flip-flop **712**, an exclusive OR gate **714**, a flip-flop **716**, a flip-flop **722**, an exclusive OR gate **724**, a flip-flop **726**, a flip-flop **730**, a collision detection state machine **750**, and a clock generation circuit **760**. Flip-flop **712** is a D-type flip-flop having a D input connected to the output of buffer **624**, a clock input for receiving a signal labeled "$\overline{\text{TS\_CLK}}$", a Q output, and an unused $\overline{Q}$ output. Exclusive OR gate **714** has a first input connected to the Q output of flip-flop **712**, a second input, and an output. Flip-flop **716** is a D-type having a D input connected to the output of exclusive OR gate **714**, a clock input for receiving a signal labeled "TS_CLK", a Q output, and an unused $\overline{Q}$ output. Flip-flop **722** is a D-type flip-flop having a D input connected to the output of buffer **628**, a clock input for receiving the $\overline{\text{TS\_CLK}}$ signal, a Q output, and an unused $\overline{Q}$ output. Exclusive OR gate **724** has a first input connected to the Q output of flip-flop **722**, a second input, and an output. Flip-flop **726** is a D-type flip-flop having a D input connected to the output of exclusive OR gate **724**, a clock input for receiving the TS_CLK signal, a Q output, and an unused $\overline{Q}$ output. Flip-flop **730** is a D-type flip-flop having a D input for receiving an output data signal, a clock input for receiving a signal labeled "TS_CLK_D", a Q output connected to the

second inputs of exclusive OR gates **714** and **724** and to the inputs of buffers **622** and **626**, and an unused $\overline{Q}$ output.

Collision detection state machine **750** has a first input connected to the Q output of flip-flop **716**, a second input connected to the Q output of flip-flop **726**, a first output for providing an interrupt signal labeled "INT", and a second output for providing a control signal labeled "DISABLE OUTPUT". Clock generation circuit **760** includes inverters **762** and **764**. Inverter **762** has an input for receiving the TS_CLK signal, and an output for providing the $\overline{\text{TS\_CLK}}$ signal. Inverter **762** has an input connected to the output of inverter **762**, and an output for providing the TS_CLK_D signal.

Flip-flops **712** and **722** capture the values on transport stream ports **630** and **640** through readback buffers **624** and **628**, respectively coincident with the rising edge of the $\overline{\text{TS\_CLK}}$ signal. Meanwhile, flip-flop **730** functions to capture the output data coincident with the rising edge of the TS_CLK_D signal. Thus, exclusive OR gates **714** and **724** compare the outgoing data with the readback data at a point in time when they are both stable. The outputs of exclusive OR gates **714** and **724** are a logic high when the outgoing data is dissimilar to the readback data, which indicates a collision. The outputs of the exclusive OR gates **714** and **724** are then captured one-half clock cycle later in flip-flops **716** and **726**, which are active on the rising edge of the TS_CLK signal.

In response to an activation of the Q output of either flip-flop **716** or flip-flop **726**, collision detection state machine **750** detects a collision. It takes two actions in response. First, it activates the DISABLE OUTPUT signal. Control circuitry in demodulator **700** activates signals OE_X and OE_Y in partial dependence on the DISABLE OUTPUT signal such that in response to an activation of the DISABLE OUTPUT signal, the control circuitry keeps the OE_X and OE_Y signals inactive, which in turn prevents buffers **622** and **626** from driving transport stream ports **630** and **640**, respectively. These signals remain inactive until demodulator **700** is reset by the host.

The second action is that collision detection state machine **750** activates the INT signal to the host. In response, the host interrupt vector may provide a mechanism to read the registers of the demodulator die through their serial I/O ports and determine which port of which particular demodulator die was erroneously set, and take any further corrective or reporting actions it deems appropriate.

As with FIG. **6** above, the signals in demodulator **700** are merely representative of one data signal and demodulator **700** will include similar circuitry for each transport stream data signal such that collision detection state machine **750** is able to detect a collision on any data signal. In this way, it will detect the collision early, even when some or maybe most of the data is coincident between the two or more demodulators.

Providing readback buffers such as buffers **624** and **628** for each transport stream output pin allows an additional capability which will now be described.

FIG. **8** illustrates in block diagram form a receiver **800** using the demodulator die of FIGS. **6** and **7** to support a channel bonding mode. Receiver **800** includes a first MCM **810** and a second MCM **820**. First MCM **810** includes a demodulator die **812** and a demodulator die **814** whose bond pads are wire bonded to the MCM substrate as shown in FIG. **5** above. First MCM **810** has a TS_X output port illustrated by a representative MCM terminal **816** and a TS_Y port illustrated by a representative MCM terminal **818**. Each of demodulator die **812** and demodulator die **814**

includes both a TS_X port and a TS_Y port wire bonded to the TS_X and TS_Y ports, respectively, of first MCM **810**. As shown in FIG. **8**, the host has configured the TS_X port of demodulator die **812** to be active, while the TS_Y port of demodulator die **812** is inactive. The host also configures the TS_X port of demodulator die **814** to be inactive, while the TS_Y port of demodulator die **812** is active. However, the host configures demodulator die **814** to use the TS_X port as an input port using the available readback buffers. Thus, the availability of readback buffers allows first MCM **810** to implement a function known as channel bonding in which the TS_X output of demodulator die **812** is combined with the output of the demodulator core of demodulator die **814** to form a bonded channel signal which is then provided to the TS_Y port of MCM **810**.

MCM **820** provides further channel bonding. Second MCM **820** includes a demodulator die **822** and a demodulator die **824** whose bond pads are wire bonded to the MCM substrate as shown in FIG. **5** above. Second MCM **820** has a TS_X2 port illustrated by a representative MCM terminal **826** and a TS_Y2 port illustrated by a representative MCM terminal **828**. Each of demodulator die **822** and demodulator die **824** includes both a TS_X port and a TS_Y port wire bonded to the TS_X2 and TS_Y2 ports, respectively, of second MCM **820**. As shown in FIG. **8**, the host has configured the TS_X port of demodulator die **822** to be inactive, and the TS_Y port of demodulator die **822** to be active. In the example of FIG. **8** in which three channels are bonded, the host also configures both the TS_X port and the TS_Y port of demodulator die **824** to be inactive. The host configures demodulator die **824** to use the TS_X port as an input port using the available readback buffers, and second MCM **820** extends the channel bonding to three channels.

The above-disclosed subject matter is to be considered illustrative, and not restrictive, and the appended claims are intended to cover all such modifications, enhancements, and other embodiments that fall within the true scope of the claims. For example, the MCM was described herein in the context of television receivers that receive both a satellite input as a first type of input and a terrestrial/cable input as a second type of input. In other embodiments, the receiver can support other types of signal sources. Moreover while the example above included two demodulator die, the MCM can be expanded to three or more demodulator die to support additional functions. Moreover other types of transport streams can be supported besides the MPEG and GSE streams described above. Also a variety of package types such as BGA, micro-BGA, quad flat-pack (QFP), quad flat no-leads (QFN) and the like may be used for the MCM.

Thus, to the maximum extent allowed by law, the scope of the present invention is to be determined by the broadest permissible interpretation of the following claims and their equivalents, and shall not be restricted or limited by the foregoing detailed description.

What is claimed is:

1. A multi-chip module (MCM) for a multi-mode receiver comprising:

an MCM substrate having first and second satellite input ports, first and second terrestrial/cable input ports, and first and second transport stream ports;

a first demodulator die having a satellite port coupled to said first satellite input port of said MCM substrate, a terrestrial/cable port coupled to said first terrestrial/cable input port of said MCM substrate, and first and second transport stream ports coupled to said first and second transport stream ports of said MCM substrate; and

a second demodulator die having a satellite port coupled to said second satellite input port of said MCM substrate, a terrestrial/cable port coupled to said second terrestrial/cable input port of said MCM substrate, and first and second transport stream ports coupled to said first and second transport stream ports of said MCM substrate.

2. The MCM of claim **1** wherein each of said first demodulator die and said second demodulator die comprises:

a demodulator core responsive to an input from a selected one of said satellite port and said terrestrial/cable port for providing a transport stream signal; and

a switching circuit for coupling said transport stream signal to a selected one of said first and second transport stream ports.

3. The MCM of claim **2** wherein said demodulator core comprises:

a configuration register operative to configure the switching circuit to couple said transport stream signal to said selected one of said first and second transport stream ports.

4. The MCM of claim **3** wherein said demodulator core comprises:

a serial port coupled to said configuration register for receiving said at least one configuration bit from a serial input/output port and storing said at least one configuration bit in said configuration register.

5. The MCM of claim **1** wherein said MCM substrate comprises a leadframe and a plastic encapsulant covering said first demodulator die, said second demodulator die, and said MCM substrate.

6. The MCM of claim **1** wherein each of said first and second transport stream ports comprise a plurality of terminals conducting signals corresponding to signals of a Motion Picture Experts Group (MPEG) transport stream.

7. The MCM of claim **1** wherein:

said second demodulator die includes a demodulator core that provides a transport stream signal in response to an input signal received at one of said satellite port and said terrestrial/cable port

in response to a channel bonding mode, said second demodulator die receives readback data from said first transport stream port of said MCM substrate, combines said readback data with said transport stream signal to form a bonded channel signal, and provides said bonded channel signal to said second transport stream port of said MCM substrate.

8. The MCM of claim **1** wherein:

said second demodulator die includes a demodulator core that provides a transport stream signal in response to an input signal received at one of said satellite port and said terrestrial/cable port

in a first mode, said second demodulator die provides said transport stream signal to said first transport stream port of said MCM substrate; said second demodulator die comprises a first readback buffer coupled to said first transport stream port thereof; and

said second demodulator die further comprises a collision detector for comparing readback data received from said first readback buffer with outgoing data corresponding to said transport stream signal, and detecting a collision in response to a mismatch between said readback data and said transport stream signal.

9. The MCM of claim **8** wherein:

in a second mode, said second demodulator die combines readback data received from said first readback buffer

with said transport stream signal to form a bonded channel signal, and provides said bonded channel signal to said second transport stream port of said MCM substrate.

10. A multi-chip module (MCM) for a multi-mode receiver comprising:

an MCM substrate having first and second satellite input ports, first and second terrestrial/cable input ports, and first and second transport stream ports;

a first demodulator die; and

a second demodulator die,

wherein each of said first and second demodulator die include:

a first input port coupled to a respective one of said first and second satellite input ports of said MCM substrate;

a second input port coupled to a respective one of said first and second terrestrial/cable input ports of said MCM substrate;

a first transport stream port coupled to said first transport stream port of said MCM substrate;

a second transport stream port coupled to said second transport stream port of said MCM substrate;

a demodulator core responsive to an input from a selected one of said first input port and said second input port for providing a first transport stream signal to an output thereof; and

a switching circuit for coupling said output of said demodulator core to a selected one of said first and second transport stream ports while keeping another one of said first and second transport stream ports in a high impedance state.

11. The MCM of claim 10 wherein said demodulator core comprises:

a configuration register operative to configure the switching circuit to couple said transport stream signal to said selected one of said first and second transport stream ports.

12. The MCM of claim 11 wherein said demodulator core comprises:

a serial port coupled to said configuration register for receiving said at least one configuration bit from a serial input/output port and storing said at least one configuration bit in said configuration register.

13. The MCM of claim 10 wherein said MCM substrate comprises a leadframe and a plastic encapsulant covering said first demodulator die, said second demodulator die, and said MCM substrate.

14. The MCM of claim 10 wherein each of said first and second transport stream ports comprise a plurality of terminals conducting signals corresponding to signals of a Motion Picture Experts Group (MPEG) transport stream.

15. The MCM of claim 10 wherein:

said demodulator core of said second demodulator die provides a transport stream signal in response to an input signal received at one of said satellite port and said terrestrial/cable port

in response to a channel bonding mode, said second demodulator die receives readback data from said first transport stream port of said MCM substrate, combines

said readback data with said transport stream signal to form a bonded channel signal, and provides said bonded channel signal to said second transport stream port of said MCM substrate.

16. The MCM of claim 10 wherein:

said demodulator core of said second demodulator die provides a transport stream signal in response to an input signal received at one of said satellite port and said terrestrial/cable port

in a first mode, said second demodulator die provides said transport stream signal to said first transport stream port of said MCM substrate; said second demodulator die comprises a first readback buffer coupled to said first transport stream port thereof; and

said second demodulator die further comprises a collision detector for comparing readback data received from said first readback buffer with outgoing data corresponding to said transport stream signal, and detecting a collision in response to a mismatch between said readback data and said transport stream signal.

17. The MCM of claim 16 wherein:

in a second mode, said second demodulator die combines readback data received from said first readback buffer with said transport stream signal to form a bonded channel signal, and provides said bonded channel signal to said second transport stream port of said MCM substrate.

18. A method for making a multi-chip module (MCM) for use in a multi-mode receiver comprising:

providing an MCM substrate having first and second satellite input ports, first and second terrestrial/cable input ports, and first and second transport stream ports;

attaching a first demodulator die to a top side of said MCM substrate, said first demodulator die having a satellite port coupled to said first satellite input port of said MCM substrate, a terrestrial/cable port coupled to said first terrestrial/cable input port of said MCM substrate, and first and second transport stream ports coupled to said first and second transport stream ports of said MCM substrate; and

attaching a second demodulator die to said first demodulator die, said second demodulator die having a satellite port coupled to said second satellite input port of said MCM substrate, a terrestrial/cable port coupled to said second terrestrial/cable input port of said MCM substrate, and first and second transport stream ports coupled to said first and second transport stream ports of said MCM substrate.

19. The method of claim 18 wherein:

said attaching said first demodulator die to said top side of said MCM substrate comprises attaching using bond wires; and

said attaching said second demodulator die to said first demodulator die comprises attaching using a non-conductive adhesive film to allow said bond wires to extend through said non-conductive adhesive film.

20. The method of claim 18 further comprising:

forming an encapsulant over said MCM substrate, said first demodulator die, and said second demodulator die.

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